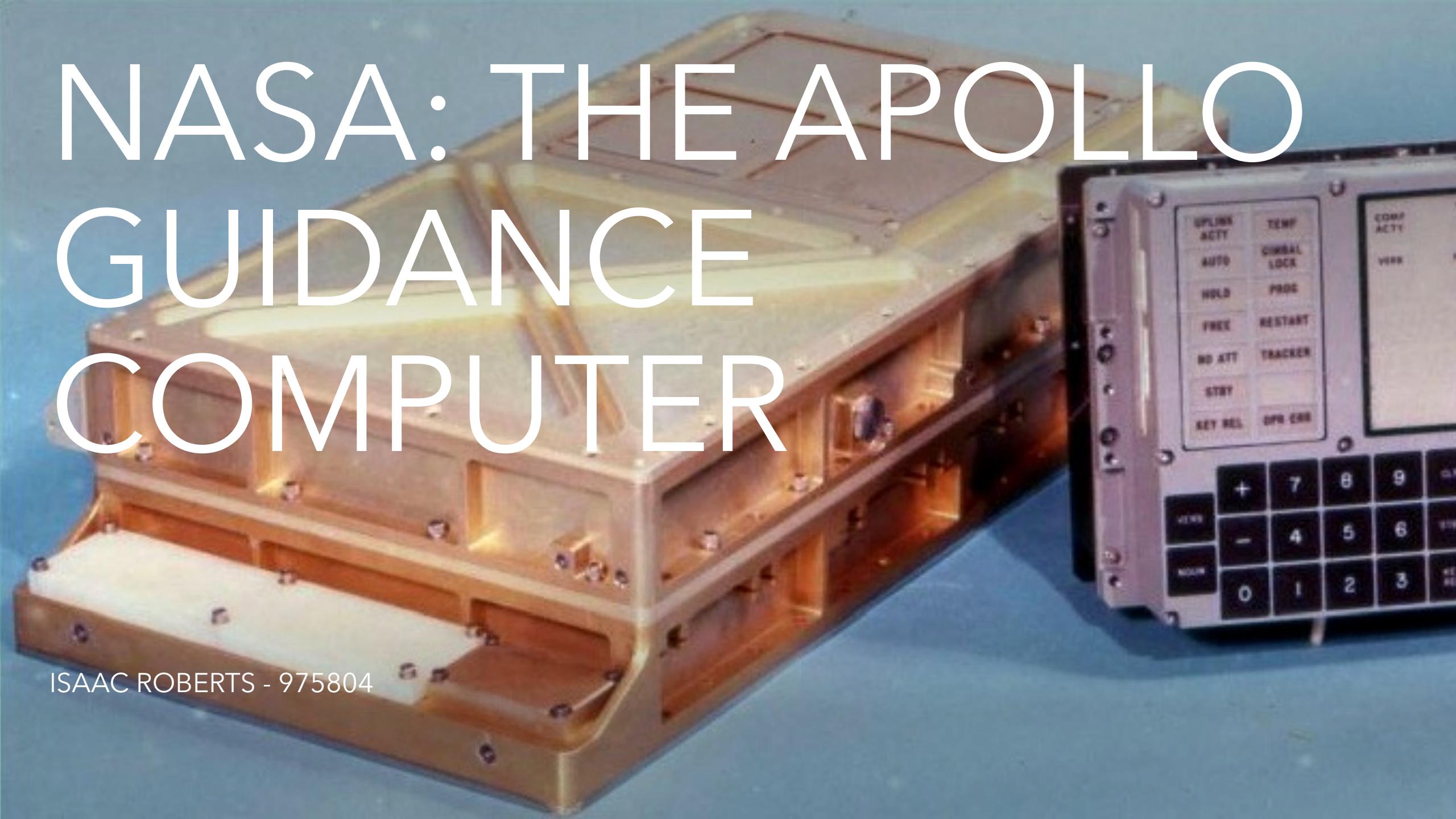
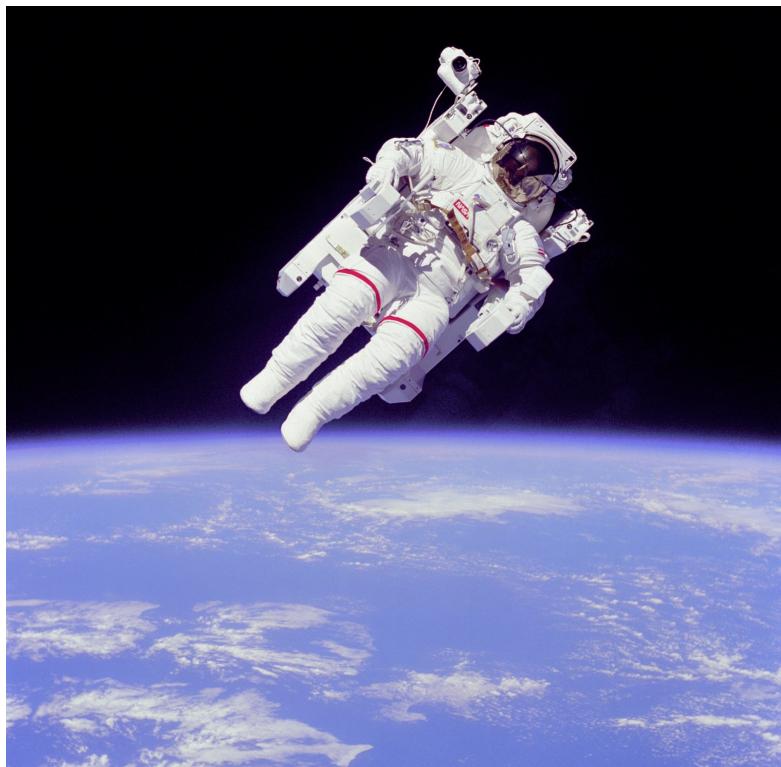


NASA: THE APOLLO GUIDANCE COMPUTER



ISAAC ROBERTS - 975804

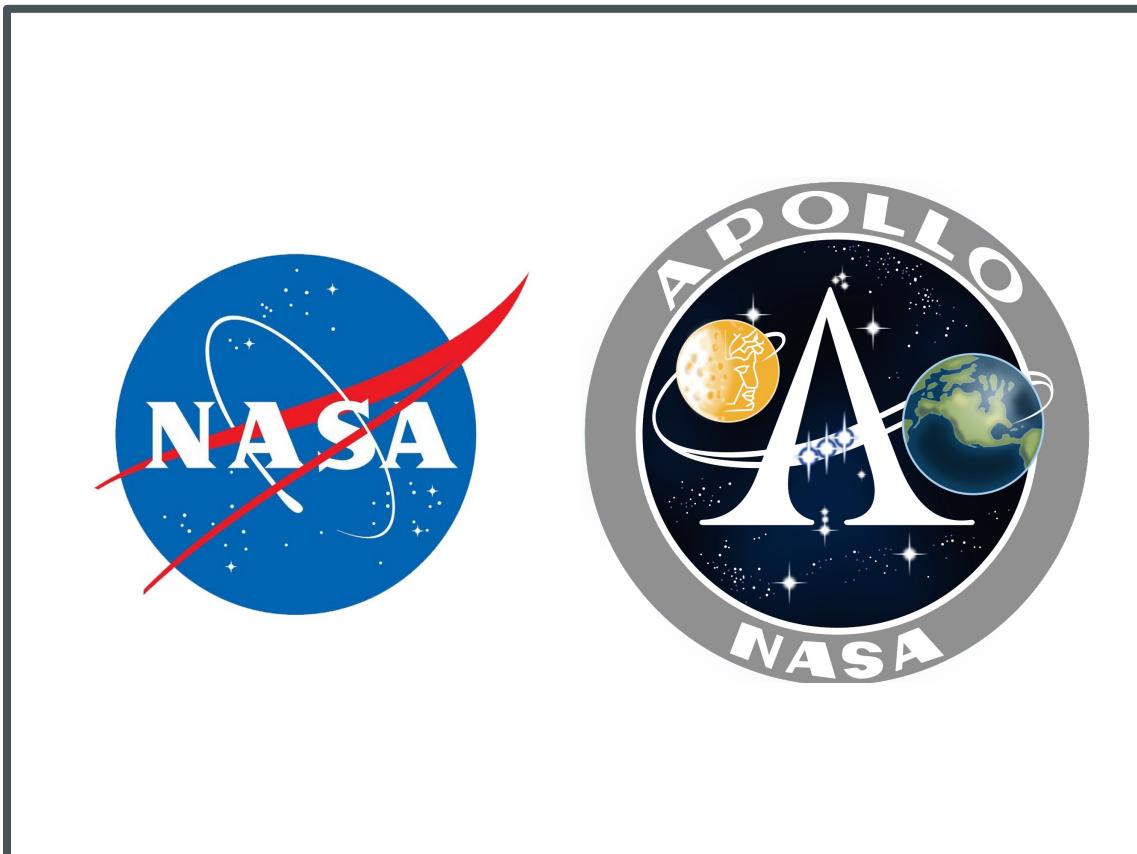
WHY THIS TOPIC?



- Reasons:
 - Important part of history
 - Contributed to the first moon landing
 - Not many people know about the technology

- Personal Reasons:
 - Young Isaac wanted to be an astronaut ☺
 - Watched films and read books set in space

BACKGROUND INFORMATION

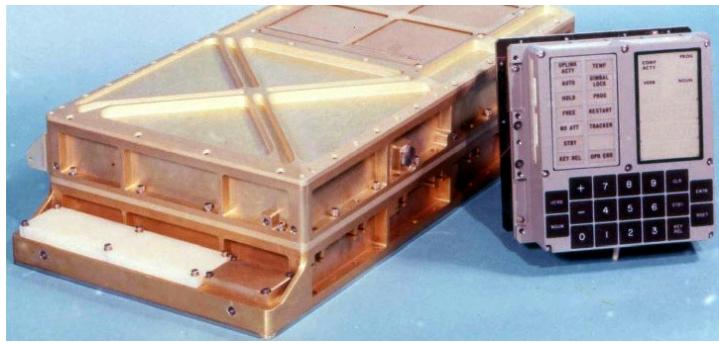


NASA

- Established in 1958
- Succeeded the NACA - NASA more civilian orientation, encourage peaceful applications in space science
- Most US space exploration efforts led by NASA

Apollo Program

- Third US Human spaceflight program (by NASA)
- Ran from 1961 to 1972
- Dedicated to President John F. Kennedy's national goal: "landing a man on the moon and returning him safely to Earth"

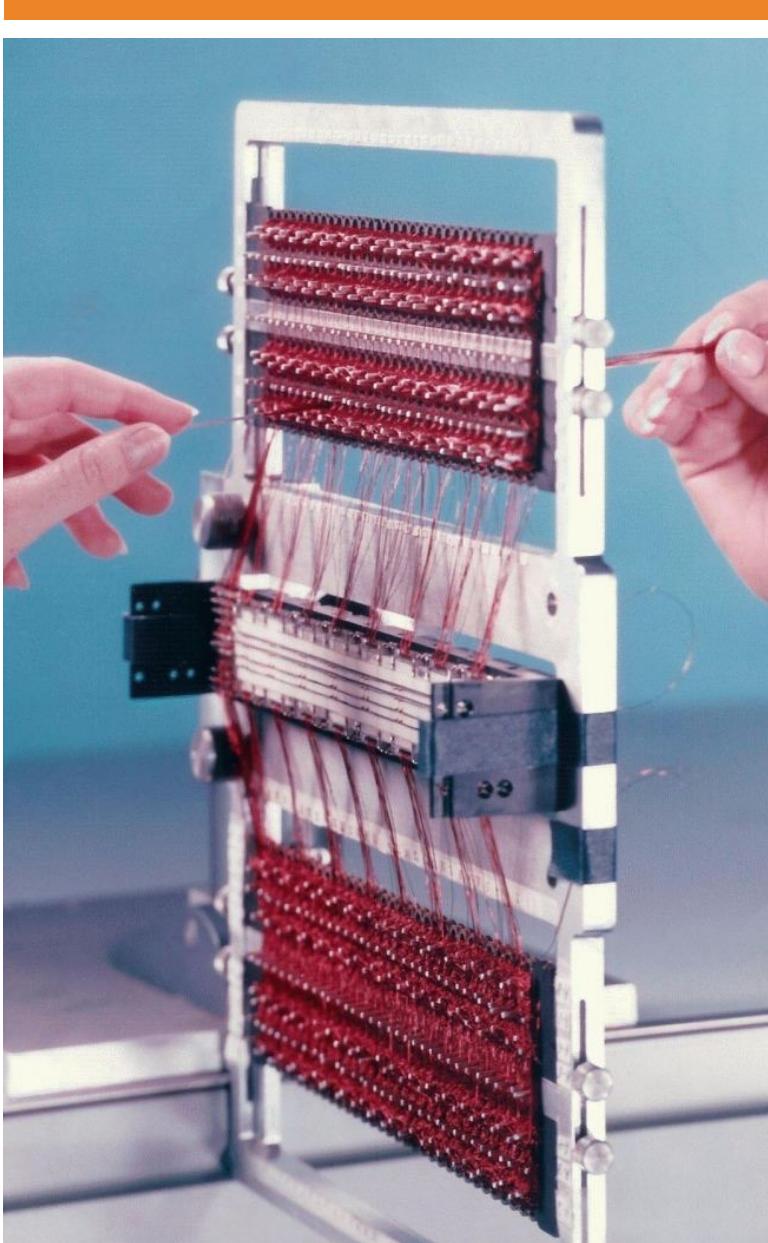


WHAT IS THE APOLLO GUIDANCE COMPUTER (AGC) ?

- Previously astronauts flew with control sticks, during Apollo computers flew most of the project
- **Put simply:** A digital computer produced for the Apollo program
- Installed on board each Apollo Command Module and Apollo Lunar Module
- Provided computation and electronic interfaces for guidance, navigation, and control of the spacecraft

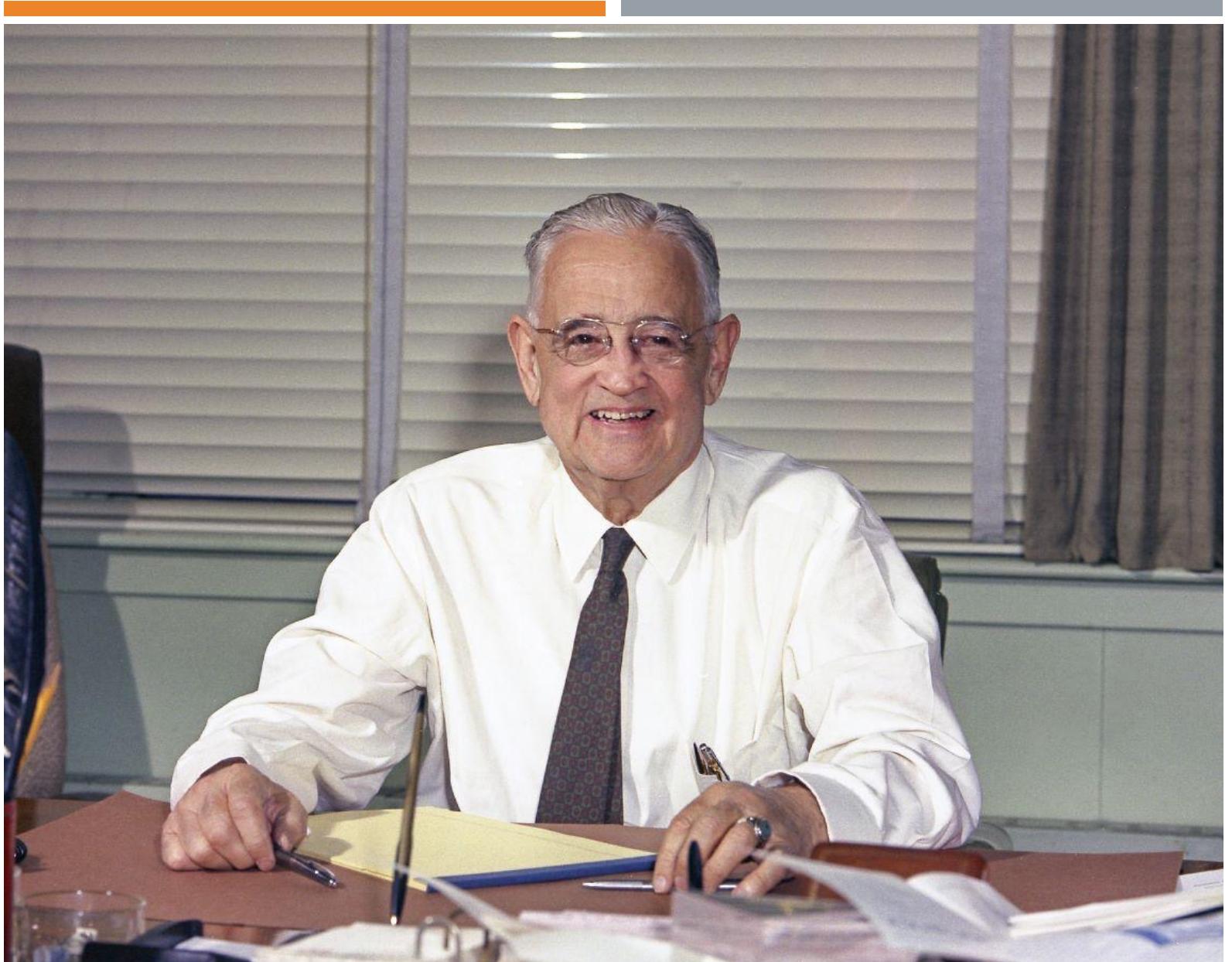
AGC DESIGN - MIT LAB

- Designed at the MIT Instrumentation Laboratory, under Charles Stark Draper (early 1960s)
- Hardware design led by Eldon C. Hall
- Architectural work was a bigger group of people
- Flight hardware made by Raytheon



CHARLES STARK DRAPER

- Born 2nd October 1901
- BA in psychology (Stanford), BSc in electrochemical engineering, Master of Science and a PHD in physics (MIT)
- American Scientist and Engineer
- Founder and director of MIT instrumentation Laboratory
- 1961 given contract for Apollo Program
- Died 25th July 1987



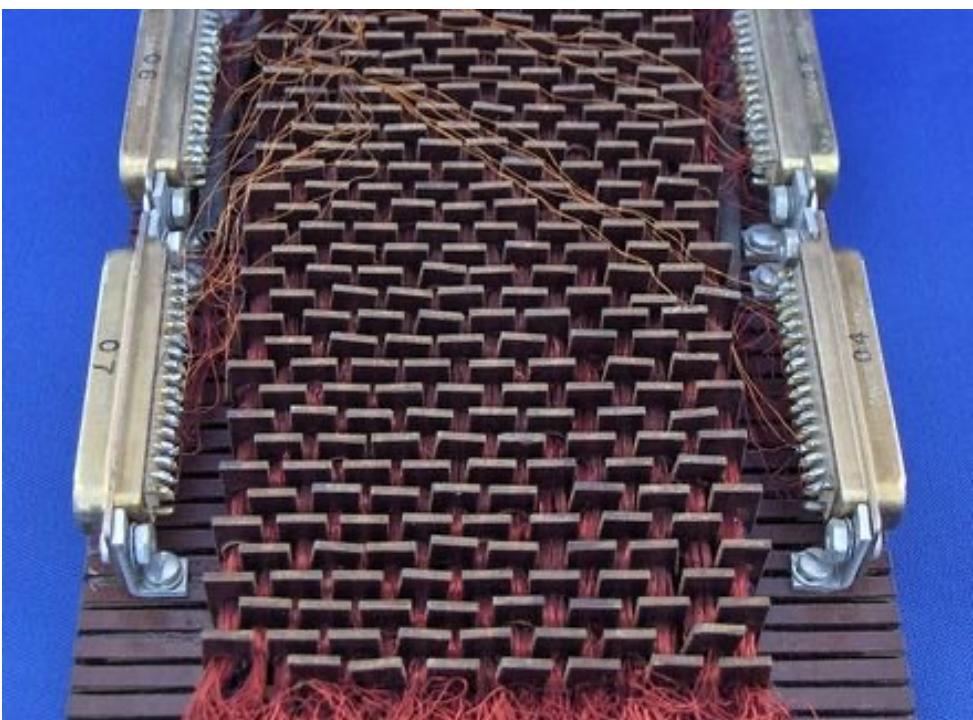
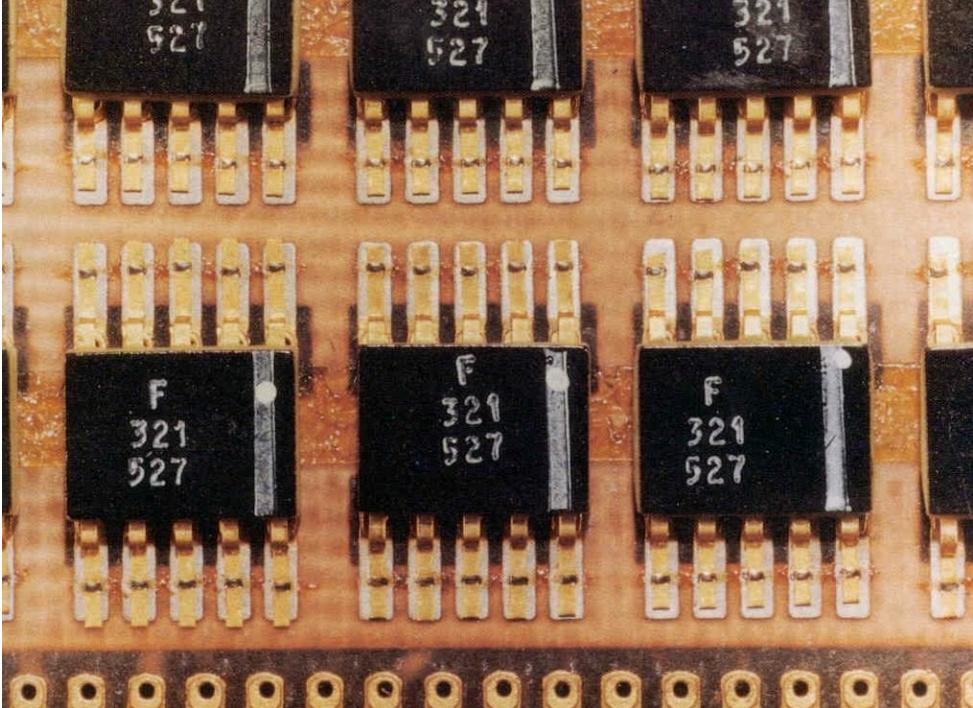


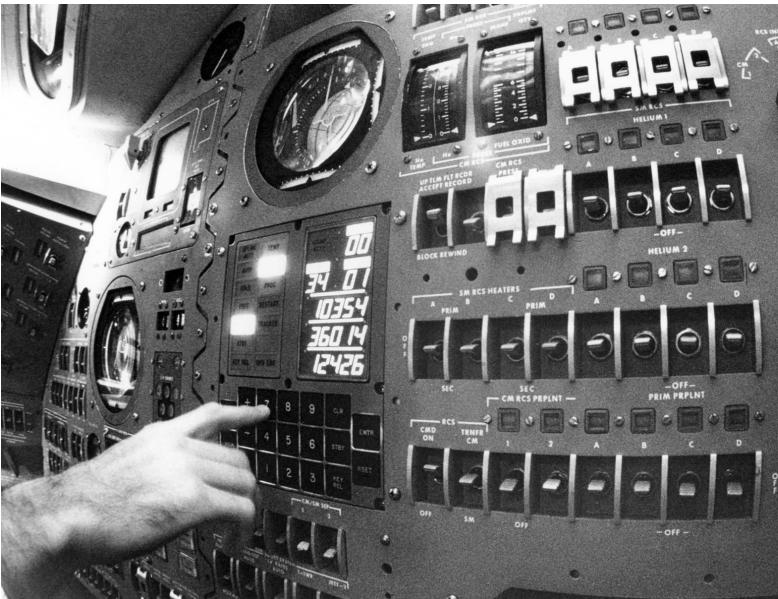
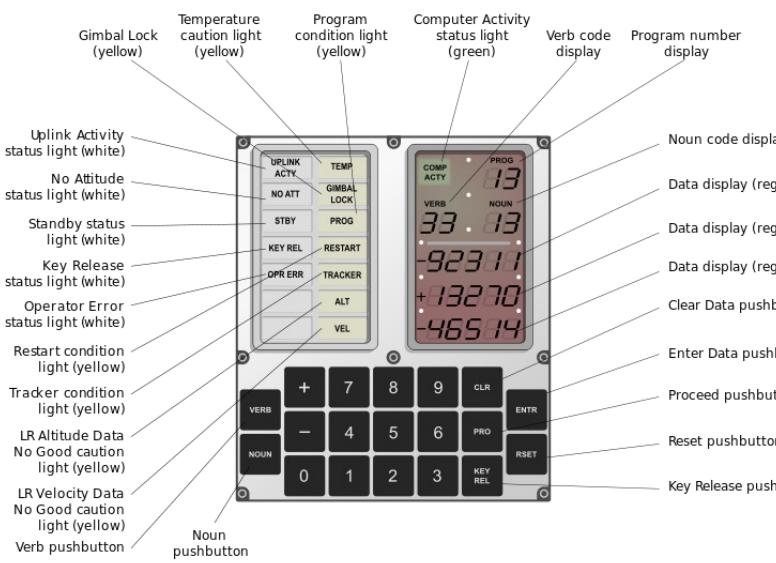
ELDON C. HALL

- Leader of the hardware design for the AGC
- Undergraduate at Nazarene College, graduate education at Boston University and his PHD at Harvard
- Learned digital computer engineering from scratch
- Pushed for integrated circuits
- Retired 1988

Apollo Guidance Computer Specs

- 2048 words of memory (RAM)
 - 16-bit word length, 15 bits 1 parity bit
- 72 KB of ROM
 - Stored most of the software, known as core rope
- Processor was a silicon integrated circuit
 - Processor ran at 0.043 MHz





HOW DID THE ASTRONAUTS USE IT?

- Astronauts communicated with the computer using a numeric display and keyboard (DSKY)
- The computer used an operating system that allowed the astronauts to type in nouns and verbs that were translated into instructions for their spaceship
- Numbers could be displayed in octal or decimal
- To control the hardware, AGC had built-in machine code instructions using a compiler called Luminary
- Luminary was developed by a team led by Margaret Hamilton

DEMO



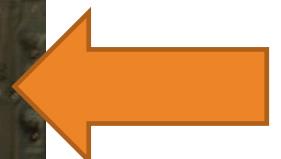
MARGARET HAMILTON

- Born 17th August 1936
- American computer scientist
- Earned a BA in Mathematics from Earlham College
- Director of Software Engineering of the MIT Instrumentation Laboratory
- 2016 received Medal of Freedom from President Barack Obama for her work during the Apollo missions



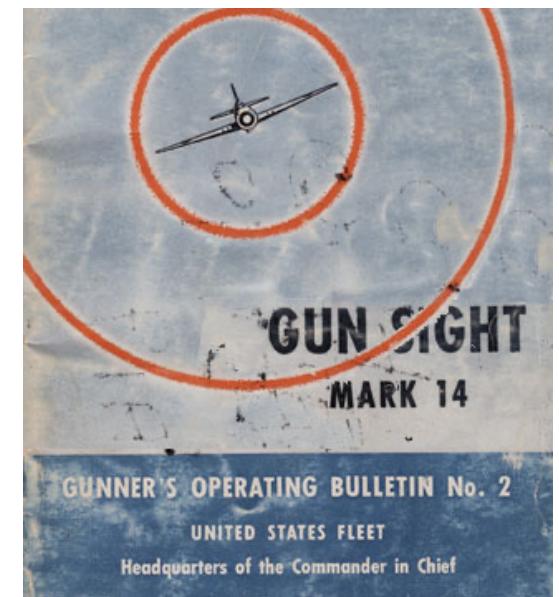
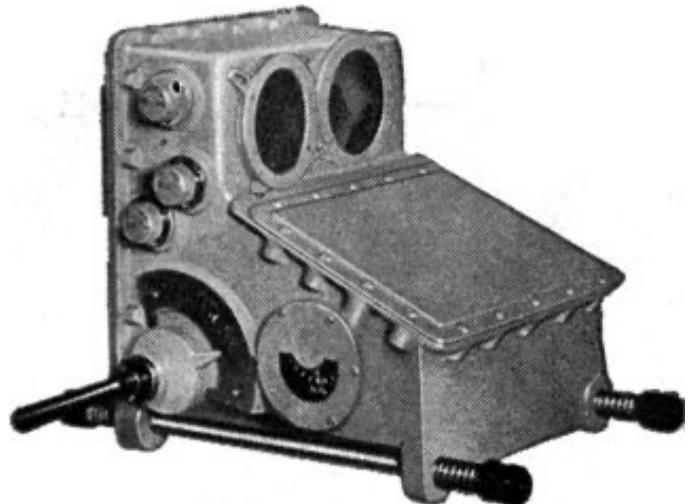
VERSIONS

- BLOCK I & BLOCK II
- Block II version designed in 1966
- Retained basic architecture
- Increased erasable memory, fixed memory
- Block II was used to fly to the moon
- Block I was used during Apollo 4, 6 and 1.



TIMELINE - 1930-1940S

- Dr. Charles Stark Draper created teaching lab for his aeronautics classes at MIT
 - Gave students a chance to have hands on experience
- Overtime became a full-time laboratory to develop instrumentation for aircraft investigation
- During WW2, the lab expanded and moved into an old Shoe Polish Factory
 - Became known as the Confidential Instrument Development Laboratory
 - Produced early guidance system and gyroscopic equipment - Mark 14 Gunsight



TIMELINE - 1950S

- Designed and built a small prototype probe
- Probe used a small computer for navigation
- Approached US Air force - not interested ☹
- Meetings with NASA



© Peter Simon

TIMELINE - 1950S CONTINUED

- Meeting with Dr. Charles Stark Draper
- Get the astronauts involved
- Worried about Soviet Union interference



TIMELINE - 1960S



Project Apollo is born!



Contract signed



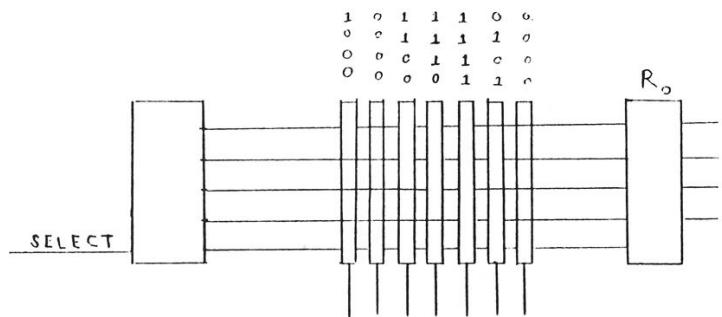
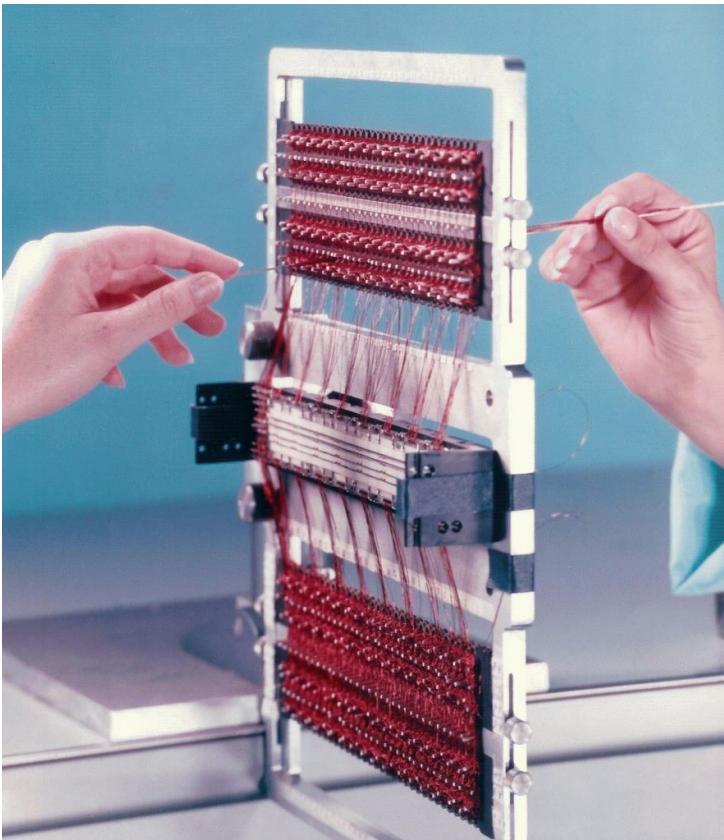
Lots of questions



Reliability?

FALL OF 1964

- New upgraded version of the AGC
- Integrated circuits invented 1959
- Core rope memory, LOL method
- Slow process
- Memory was reliable but there were problems



TIMELINE - 1965+

- Block 1 installed on spacecraft
- Release of first software (Jan 1966)
- First flight 25th August 1966
- Block II



APOLLO 11 & THE 1202 PROGRAM ALARM

- Launched July 16
- Fifth crew mission of the Apollo Program
- Stages:
 1. Launch
 2. Lunar orbit
 3. Lunar descent
 4. Landing
 5. Return to Earth



WHAT ELSE WAS IT USED FOR?

- F-8 Crusader
 - Experimental fly-by-wire system
- Navy
 - Rescue vehicle



CONCLUSION & FINISH

Thanks for listening, any
questions? ☺



SOURCES

1. Apollo Guidance Computer Image, Grabert, German Wikipedia, 2005.
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